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**ASSESSMENT OF HYDROCARBON SEEPAGE ON LANDS
BELONGING TO FT. PECK TRIBES: SOIL GEOCHEMISTRY
APPLICATION ON AEROMAGNETIC LANDSAT LINEAMENT, AND
3D SEISMIC ANOMALIES**

Semi-Annual Report
June 15, 2000-December 15, 2000

By:
Lawrence M. Monson

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Assiniboine and Sioux Tribes
Poplar, Montana 59255



**National Energy Technology Laboratory
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Tulsa, Oklahoma**

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Assessment of Hydrocarbon Seepage on Lands Belonging to Ft. Peck Tribes: Soil Geochemistry
Application on Aeromagnetic Landsat Lineament, and 3d Seismic Anomalies

By
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Work Performed Under Contract DE-FG26-00BC15192

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ABSTRACT

This is the first semi-annual Technical Progress Report for DOE Grant No. DE-FG-26-00BC15192 entitled "*Assessment of Hydrocarbon Seepage on Lands Belonging to Ft. Peck Tribes: Soil Geochemistry Application on Aeromagnetic Landsat Lineament, and 3D Seismic Anomalies*". In this initial six month time period the principle contractor for the project, the Assiniboine and Sioux Tribes, performed the following work: 1) Identified three test areas for Phase I, 2) Selected nine surface exploration methods for comparison, 3) contracted six geochemical companies for laboratory analysis and interpretation, 4) sub-contracted one surface geochemical method for field collection and analysis, 5) Acquired free data for one surface exploration method, 6) Collected samples from 27 sites in Area 7 and 210 sites in Area 6, and 7) Began the database creation, comparison, mapping, and interpretation of all data from the two sampled areas.

EXECUTIVE SUMMARY

Three of the fifteen proposed areas were selected for Phase I surface sampling. These included: 1) Area 7, which lies above a producing oil field, 2) Area 6, which contains two 3D seismic anomalies, and 3) Area 1, which features numerous geologic, geophysical, and surface features associated with a 6 mile diameter, aeromagnetic anomaly. The following hydrocarbon detection methods were chosen for comparison:

1. Free soil gas survey. [SG]
2. Soil acid extraction of gases. [AE]
3. Soil UV Fluorescence. [F1]
4. Soil Magnetic Susceptibility. [MS]
5. Soil Microbial Measurement. [M1]
6. Soil Iodine. [I]
7. Soil head gas analysis of basic hydrocarbons. [HG]
8. Measurement of Soil supplemental indicators: Eh, PH, and Conductivity. [E], [P], [K] respectively.
9. Magneto-Tellurics measurement of electromagnetic energy. [MT]

The last method was included free of charge as part of a demonstration prospecting permit and is only available for Area 7. Samples from Area 7 were also sent to a second fluorescence company [F2] to another company utilizing thermal desorption techniques [TD], and to another company for microbial measurement [M2].

The hydrocarbon detection techniques all employ the use of ratios of gases and in one case, detailed statistical normalization. Some companies provided interpretative reports and maps while

detailed statistical normalization. Some companies provided interpretative reports and maps while some companies discounted for only providing the analytical results. All discounted for client field sampling which saved as much as 30% plus transportation costs.

Two methods were not employed in Phase I because the provider of the service had to collect the data. There was insufficient time and not enough funding in Phase I to complete these techniques: 1) Resistivity mapping and 2) A micro-magnetic survey.

Head gas samples collected by power auger correlate the best to oil production and to 3D seismic anomalies.

Thermal Desorption analysis correlates well to production.

Direct soil gas measurements are five to ten times less sensitive and do not correlate as well to either production or to the seismic anomalies.

Both *microbial* methods show depletion over the oil field. One 3D anomaly was confirmed in Area 6.

Acid extract gases are depleted over the oil field and correlate partially to the 3D anomalies, but also show a strong halo pattern.

Iodine, magnetic susceptibility, and UVF methods are difficult to interpret. These show depletion and halo anomalies.

Eh, pH, and Conductivity show halo/depletion or inverse anomalies over production and only Eh confirms gas seepage over 3D anomalies.

PHASE I INTERIM REPORT
Fort Peck Reservation Assessment
Semi-Annual Progress Report

By Lawrence M. Monson

INTRODUCTION

Under the original proposed Statement of Work it was anticipated that this report would summarize the entire Phase I portion of the project which was designed to compare multiple surface methods in at least three areas. Because only two areas were sampled, this report should be viewed only as an interim progress report and not the completion of Phase I. Several factors contributed to this variance from the proposed Statement of Work objectives and time schedule:

26. Grant funding, which was awarded in December of 1999, was not received until late June of 2000, thus delaying the hiring of a Field Assistant, enlisting geochemical subcontractors, and starting field sample collection.
27. The project Field Geologist resigned in August causing the Supervisor to assume that responsibility once other commitments were completed.
28. The project field work plan was completely reorganized to accommodate items 1) and 2). In order to maximize the analytical funding, most samples were collected by the prime contractor.

Despite these changes, samples were collected analyzed, and the interpretation begun, for two areas. This report will list and summarize the methods selected, the areas sampled, and record initial data comparison observations. Please view slides 1, 2, and 3.

TECHNICAL DESCRIPTION OF WORK

Experimental

Slide 4 displays the sample sites chosen on the Fort Peck Reservation for the comparison of surface hydrocarbon exploration techniques. Area 7 was selected because it lies above the Palomino Oil Field which is still free-flowing under natural water drive and thus an excellent area to test whether hydrocarbon gases have, and are, seeping from the earth. Area 6 is the site of two 3D seismic anomalies mapped by the Tribes' exploration partner, Gulf Canada. These were the only two areas sampled in Phase I.

A brief summary of the methods chosen for comparison is listed in Slide 5. A more extensive comparison of the procedures, analytical techniques, data reported, and comments can be seen in Table 1. Table 6 summarizes the theoretical basis behind each hydrocarbon indication method. All samples were collected by Tribal personnel and sent to respective labs for analysis. The soil gas survey was done by a sub-contractor. All analytical sub-contractors provided data tables by e-mail and, or FAX transfer. The Head Gas sub-contractor supplied detailed and complete statistical analysis and full-color maps for selected data sets. Both Microbial sub-contractors prepared maps and statistical analyses. The Acid Extract company also prepared a thorough statistical review. Details of the sampling procedure and the hydrocarbon indication theory are organized in Table 2. Photographs of the lab and field operations are contained in Slides 7-10.

Results and Discussion

Area 7

Area 7, the Palomino Oil Field, was sampled in four intersecting traverses containing 27 collection points. These were centered on the field's best oil well, Tribal Bird 1-7, which has produced 1.4 million barrels of oil. A "blind" comparison test consisted of three samples collected at the same location, at different times. Analytical sub-contractors were not told in advance where the wells were, nor about the triplicate test. Some may have independently researched the area and plotted sample sites before analyzing the samples. Throughout this report the word "anomaly" refers to contoured map areas of values, usually greater, that indicate gas micro-seepage from the earth.

Slides 11-13 show the location, geologic contour map, and topography of the Palomino Field, respectively. Propane was chosen for comparison purposes and data values were contoured in Slide 14 for each of the four methods which analyzed for this gas. Head Gas best correlated with oil production. Acid Extract inversely correlated, revealing depletion by 20 years of production. Thermal Desorption partially correlates with production, but has an anomaly perpendicular to the Head Gas trend. This method and the Soil Gas Survey show depletion over the oil field and have elevated gas values to the northwest. The sample sites are plotted on the left side map of Slide 14. Both Microbial methods are mapped in Slide 15. They show anomalies in different places close to current oil production, but generally confirm depletion over the field. The anomalies may indicate infill or offset drilling locations. Table 3 is a complete summary of the results for Area 7. For propane, the Head Gas method best correlated with production. The Thermal Desorption method-4-

best reproduced propane results in the Triplicate Test. Slide 16 graphs propane for the four methods. The relatively small values and incomplete detection of the Soil Gas Survey data is noticeable. Head Gas and Thermal Desorption are relatively parallel while Acid Extract data is remarkably inverse in relation to these two.

Area 6

Area 6 is significant to the Assiniboine and Sioux Tribes because it lies within the largest block of land that they own on the Fort Peck Reservation. Slide 7 locates Area 6 in the north-central part of the reservation in an unexplored region. The basis for this selection as a test area is highlighted in Slide 18. The primary 3D seismic anomaly, named "Tobago", closes on the east side of the map. A secondary feature, called "Trinidad" occurs 1.5 miles west, but lacks four-way time closure. A large structural nose protruding from the northwest also bears hydrocarbon trapping potential, but was not sampled due to the large areal extent. 210 locations, along 18 east-west profiles, were sampled for the methods listed in Table 4. (See Slide 19 for the Area 6 base map with sample sites) Coincidentally, the two 3D anomalies straddle the Poplar River along highlands running parallel to the valley. Slide 20 displays four field views.

Propane is again the featured gas in Slide 21 which compares the three direct hydrocarbon detection methods employed in evaluating Area 6. The Head Gas data anomalies strongly correlate with both seismic prospects. Acid Extract data appears to surround the eastern anomaly as a halo, but closer examination shows this method to have relatively high values over the "Tobago" prospect. The Soil Gas Survey produced ambiguous results with possibly a small hydrocarbon anomaly over Tobago. Slide 22 graphically compares the propane data along profile line I which intersects both 3D seismic anomalies. The Soil Gas Survey found no propane in some locations and measured values several times smaller than the other two methods. Acid Extract data often plots in an inverse relationship to the Head Gas data suggesting that this method maps a halo anomaly around hydrocarbon seepage.

Indirect hydrocarbon indicators are mapped in Slide 23: I = Iodine, MS = Magnetic Susceptibility, M1 = Microbial, UVF - UV Fluorescence. All but UVF show elevated values over the eastern 3D anomaly. UVF appears to be higher in the river valley and may be mapping faults that are leaking heavier hydrocarbon gases. Three other indirect indicators are displayed in Slide 24. Here only Eh (oxidation/reduction potential) appears useful in delineating hydrocarbon micro-seepage. (See section 22 on the map)

Slide 25 displays three views of a spring and drainage filled with a black "oily" water. Laboratory analysis of the water confirmed the surface geology observation of a coal seam in the base of the western valley outcrops. This area also had higher methane values, which is likely associated with the coal. An active oil seep would have created tremendous exploration interest and confirmed the viability of the projects' surface exploration techniques. It would also have made them unnecessary.

Table 4 is a detailed comparison of the surface exploration methods utilized in Area 6. Data statistics and anomaly classification are included for both 3D seismic anomalies. Head Gas analysis again provided the best correlation to what is hoped will be a new hydrocarbon discovery on Fort Peck Tribal lands.

CONCLUSION

Phase I Preliminary Observations are found on Slide 26. Area 7 and Area 6 data will be further interpreted using statistical ratios rather than absolute values. Phase II of the project has begun with sampling of Area 1 from what was learned in Phase I. A Micro-Magnetic survey will be conducted in late June and the Head Gas method employed along with a Soil Gas Survey. Selected sites will be sampled for microbes and Iodine. It is planned to also sample another 3D seismic prospect and at least two shallow gas prospects.

TABLE 1: Exploration Methods
Fort Peck DOE Grant

METHOD	SAMPLING PROCEDURE	ANALYTICAL TECHNIQUE	DATA REPORTED	COMMENTS
1. Free soil gas [SG]	Milled 3 ft. steel pipe with slotted replaceable tip driven into ground with slide hammer. Syringe inserted through replaceable septa and air sample extracted after air is purged from pipe. Syringes transported in padded box.	Soil gas analyzed daily by portable baseline 1030A flame ion gas chromatograph. Empty probe samples run for checks. Output graph and molecular weight by % printed. Quantified in relation to research grade calibration gas.	Methane (ppb) Ethane Propane IsoButane N-Butane	Some samples lost due to power failures. Some gases not detected due to power spikes.
2. Soil Acid Extract [AE]	Soil samples collected from spade hole and placed in steel pint cans with biocide solution. Sealed.	Wesson and Armstrong procedure. Sub-samples retrieved, reacted with HCl and heated. Flame ion detector gas chromatograph used.	Methane (ppm) Ethane Ethylene Propane Propylene I-Butane N-Butane	Benzalconium chloride used as biocide to kill microbial bacteria that might consume H/C molecules.
3. UV Soil Fluorescence [F1]	(same as acid extract)	Sub-samples air dried for 24 hrs. Polycyclic aromatic compounds extracted with non-polar solvents. Analysis by spectrophotometer.	Naphthalene (ppb) (2-ring PAC) Phenanthrene (3-ring PAC)	Heavier hydrocarbon molecule indicator. Could be contamination in oil field areas.
4. Magnetic Susceptibility [MS]	Soil sample collected from spade hole.	Meter measures ability of soil minerals to be magnetized.	CGS units reported.	
5. Soil Microbial [M1]	Soil samples collected from spade hole.	Culture only hydrocarbon feeding bacteria with nutrient agar for 72-96 hrs. Measure relative growth by colometric spectrophotometer.	Average raw data density value, relative average, percent ranking and model probability of success.	40 = strong 20 - 30 is significant.
6. Iodine [I]	Soil sample from spade hole.	Dry, sieve to 5 micrometers, weigh, digest to remove organics, titrate, colorimetric analysis.	Iodine (ppm)	Shallow depth.

TABLE 1: Exploration Methods - Fort Peck DOE Grant

7. Soil Head Gas [HG]	Soil samples collected by power auger, placed in sealed, double lid on 8 oz. jars separated by septum layer. Jars half filled with water. Lids have center punched 1/8" holes.	Head gas air sample extracted with syringe after gentle agitation. Air analyzed by flame ion detector gas chromatograph.	Methane Ethane Ethene Propane Propene i-Butane n-Butane i-Pentane n-Pentane	Two inch auger diameter, 36 inches long with replaceable bits.
8a. Eh [E]	Same as Head Gas	Automated specific ion electrode probe analysis.	Millivolts	
8b. PH [P]	Same as Eh	Same as Eh	pH units	
8c. Conductivity [K]	Same as Eh	Same as Eh	Micrihos units	
9. Soil Thermal Desorption [TD]	Spade hole soil sample. Placed in glass jar with teflon sealed, plastic lid.	Samples agitated and heated. Analysis by Flame Ion Detector Gas Chromatograph.	Methane Ethane Ethene Propane Propene i-Butanes n-Butane i-Pentane n-Pentane i-Hexane n-Hexane	Cumulative relative intensity calculated as oil probabilities. Analysis comparison of spectra.
10. UV Soil Fluorescence [F2]	Spade hole soil sample.	Soil dried disaggregated, and sieved for fines (clay and silt) fraction. Proprietary solvent added, agitation, centrifuge extract analyzed with synchronous scanning UV fluorescence spectrometer.		

TABLE 1: Exploration Methods - Fort Peck DOE Grant**Page 3**

11. Soil Microbial [M2]	Spade hole soil sample.	Microscopic count of butane oxidizing microbes selectively culled from other organisms present.	Microbial count value.	Samples must be kept cool or dehydrated.
12. Magneto - Tellurics [MT]	Field readings	Portable audio frequency electro-magnetic telluric receiver. (AFMAG). Coupled to digital audio tape. Basically a magnetometer with long antennae dipoles. 10-30 channels collected.	Mud-log type graphs with resistivity plotted vs. depth. Porosity calculated from resistivity in some graphs.	

TABLE 2: Exploration Details
Fort Peck DOE Grant

METHOD	SAMPLE DEPTH	SAMPLE QUANTITY	SAMPLE CONTAINER	H/C INDICATOR	THEORETICAL BASIS
1. SG	61-91 cm	5 cc	syringe	Direct/Semi-Active	Vertical microseepage of light hydrocarbons.
2. AE	15-30 cm	4 cm in pint can	steel can	Direct/Passive	Extraction of occluded light hydrocarbons.
3. F1	15-30 cm	4 cm in pint can	steel can	Direct/Passive	Extraction of fracture migrated medium wt. hydrocarbons.
4. MS	15-30 cm	150 g	zip-loc bag	Indirect/Passive	Reducing environment above H/C seep precipitates ferrous minerals that are more easily magnetized.
5. M1	20 cm	30 g	zip-loc bag	Indirect/Passive	Presence of hydrocarbon feeding bacteria detected above micro-seepage
6. I	3 cm	340 g	zip-loc bag	Indirect/Passive	Hydrocarbon gases free and adsorb iodine from minerals or atmosphere.
7. HG	61-91 cm	625 g	8 oz. jar	Direct/Passive	Hydrocarbon gases free and adsorb iodine from minerals or atmosphere.
8a. E	61-91 cm	625 g	8 oz. jar	Indirect/Passive	Extraction of adsorbed light hydrocarbons from soil dissolved in water collected above microseepage.
8b. P	61-91 cm	625 g	8 oz. jar	Indirect/Passive	Relatively reducing environment above hydrocarbon microseepage.
8c. K	61-91 cm	625 g	8 oz. jar	Indirect/Passive	Relative higher pH within and even higher pH surrounding H/C seep. Believed to be caused by calcite precipitation where weathered soils are neutralized by light H/C gas adsorption.
9. TD	15 cm	625 g	8 oz. jar	Indirect/Passive	Salts precipitated by higher pH soils at margin of microseepage anomaly.
10. F2	15 cm	625 g	Glass jar	Direct/Passive	Extraction of adsorbed hydrocarbons from soils above microseepage.
11. M2	15-22 cm	30 g	Paper envelope	Indirect/Passive	Detection of aromatic and double bonded hydrocarbons in soil above microseepage.
12. MT	Surface and inserted probes	30 minutes	Magnetic flux rod. Metallic probe.	Indirect (Active)	See M1, #5.
					Magnetic pulses passing through earth induce electric currents that are affected by stratigraphy, water, and hydrocarbons. Frequency filters are applied to detect signals from desired depths of anticipated reservoirs.

TABLE 3: DATA ANALYSIS - AREA 7

FORT PECK DOE GRANT

Method	H/C Indicator	Company Validation Technique	Range	Mean	Company Anomaly Determination	Company Anomaly Technique	Company Anomaly Value	Ethane vs. Propane	Comparative Common Anomaly Technique	Comparative Common Anomaly Value	Correlation Feature	Correlation Quality	Correlation Type	TriPLICATE Sample Correlation (3)	Comment
1. SG	Propane	Inverse relation to Thermal Desorption	0.14-1.64	0.70	Single gas Sem-log Survey log profiles	Slope increase	0.2	Poor	1.5 x mean	1.05	Oil Production	0.47-Poor	Inverse?	0.75-Poor	Only 10 samples with both ethane and propane.
2. AE	Propane	Pearson's Correlation Ethane vs. Propane	0.17-28.38	11.05	Ordered plot single gas	Break in slope (steeper)	3.0	Excellent	1.5 x mean	16.57	Oil Production	4.37-Very Poor	Inverse? (Halo)	0.59-Fair	Halo/Depletion
3. FI	PAC-3 Ring	NR	11-35	22.81	Ordered plot	Break in slope	23	N/A	1.5 x mean	34	Oil Production	23-Fair	Apical	0.27-Good	Contamination, Bird Well?
4. MS	Magnetization	NR	29-98	56.07	Ordered plot	Break in slope	60	N/A	1.5 x mean	84	Oil Production	47-Poor	Halo	0.11-Very Good	Halo/Depletion
5. M1	Microbes	Drilling success	-0.65-42.80	10.21	Correlation to production	Experience	20	N/A	1.5 x mean	15.32	Oil Production	13.94-Good	Partial Apical	0.76-Poor	Deposition with one anomalous sample.
6. I	Iodine	Drilling success data duplicates	0.1-6.8	1.7	Mean	Mean	1.7	N/A	1.5 x mean	2.5	Oil Production	1.1-Poor	Halo	0.3-Good	Halo/Depletion
7. HG	Propane	Correlation Matrix	0.23-9.43	4.30	Harmonic Mean	Twice Harmonic Mean	4.09	Excellent	1.5 x mean	6.45	Oil Production	5.09-Good	Apical	0.51-Fair	Best Correlation
8.a. E	Eh low	Consistent (-)	-7.30 to -294.50	-46.13	Harmonic Mean	Twice Harmonic Mean	-108.41	N/A	1.5 x mean	-209.22	Oil Production	-127.51-Poor	Halo	-1.20-Very Poor	Halo/Depletion
8b. P	pH double high	Small range	6.47-7.87	7.59	Harmonic Mean	NR	NR	NR	Mean + St. Dev.	7.83	Oil Production	7.27-Good	Halo	0.04-Excellent	Well defined Halo
8c. K	Halo night	Halo to H/C Highs	392-6460	1151	Harmonic Mean	Twice Harmonic Mean	2302	N/A	1.5 x mean	1726	Oil Production	1177.83-Fair	Inverse	1.18-Very Poor	Inversed/Depletion
9. TD	Propane	Discriminate Analysis	3.22-12.96	8.74	Production Model	Avg. Nearest Samples 4, 5, 13-20	11.32	Very Good	1.5 x mean	13.12	Oil Production	9.25-Fair	Partial Apical	0.17-Very Good	Good Correlation
10. F2	UVF Intensity	Synchronous Spectral Analysis	122-577	253	Oil Probability	Sample 4, 5, 13-20	100%	N/A	1.5 x mean	380	Oil Production	286-Fair	Partial Apical	0.12-Very Good	Good Correlation
11. M2	Microbes	Standard Statistics	12-62	38	Frequency Histogram	Dual Population	40	N/A	1.5 x mean	56.8	Oil Production	34.5-Fair	Mixed	0.44-Fair	Halo and Apical
12. MT	Telluric Resistivity	Structural/Resistivity Correlation	0-28	11	Well Stations	Resistivity Log	0.5	N/A	1.5 x mean	16	Oil Production	21.6-Excellent	Apical	N/A	"Perfect" Correlation

(1) Samples surrounding Tribal Bird well, #3, 4, 12, 13, 20, 21

(2) Compared to Common Anomaly Value: >1: Excellent; 75: Good; 5: Fair; <25: Very Poor

(3) Samples 4, 13, 20 Measured. dev. 0-1: Excellent, .1-.25: Very Good, .25: Good, .5: Fair, .75: Poor, >1: Very Poor

TABLE 4: DATA ANALYSIS - AREA 6

FORT PECK DOE GRANT

Metric	H/C Indicator	Range	Mean	Common Anomaly	Enhanced Propylene	Comparative Anomaly Value (1)	Correlation Feature (2)	West Correlation Quality (3)	Correlation Type	East Correlation Feature (4)	Correlation Quality (5)	Comments
1. SG	Propane	0.035-1.91	0.51	0.42	Poor	0.76	3D High	0.42-Fair	Halo?	3D Closure	0.49-Fair	Halo
2. AE	Propane	6.05-50.07	8.69	5.23	Excellent	13.03	3D High	1.73-Very poor	Apical?/Small	3D Closure	11.16-Good	Apical w/Halo
3. FI	PAC-3 Ring	9-137	33	48	N/A	49	3D High	34-Good	Apical	3D Closure	24-Fair	Halo
4. MS	Magnetization	27-135	52	55	N/A	77	3D High	44-Fair	Apical w/Halo	3D Closure	61-Good	Halo found around structures also.
5. MI	Microbes	1.35-4.98	20.66	20	N/A	30.99	3D High	16.64-Fair	Apical	3D Closure	25.11-Good	Apical
6. I	Iodine	0.00-8.52	0.87	0.85	N/A	1.30	3D High	1.63-Good	Apical/Halo	3D Closure	0.46-Fair	Other anomalies off structures.
7. HG	Propane	0.00-46.99	3.97	0.03	Very good	5.96	3D High	5.61-Very good	Apical	3D Closure	10.47-Excellent	Apical
8a. E	Eh low	-421 to 275	47.08	-157.00	N/A	23.54	3D High	114.03 Poor	Halo	3D Closure	41.22-Good	Best correlation to seismic, especially East Prospect.
8b. P	pH double high	6.37-9.28	7.41	7.88	N/A	7.91	3D High	7.53-Good	Halo	3D Closure	7.14-Fair	Apical/Halo
8c. K	Conductivity	144-10,760	1376	1563	N/A	2065	3D High	2165-Good	Inverse Halo?	3D Closure	565-None	Topographical Influence?
	Halo High											Topographical Influence?

(1) 1.5 x mean

(2) Average of Samples J3, J4, K4-6, L3-6, M5, M6, N5, N6

(3) (2) compared to (1). >1, Excellent; .75, Good; .5, Fair; .25, Poor; <.25 Very Poor

(4) Average of Samples G13, H27, H8, H12, H13, K12-14, L10

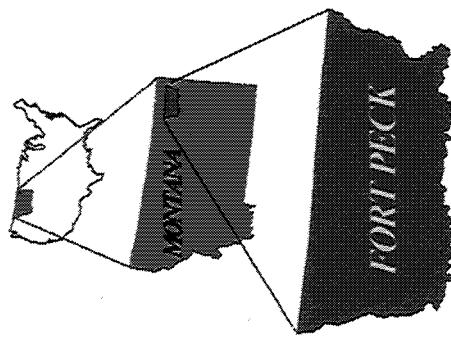
(5) (4)/(2) See (3) for qualitative description of values.

Assessment Of Hydrocarbon Seepage On Fort Peck

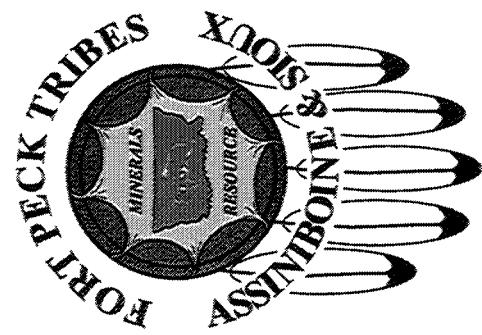
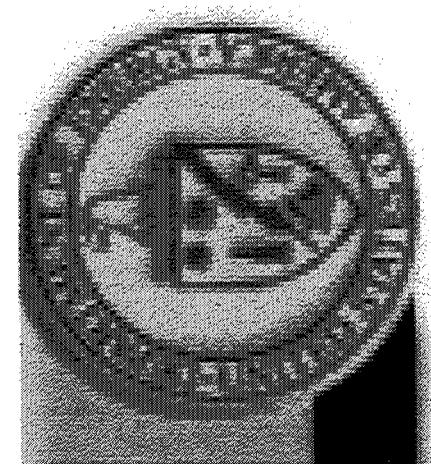
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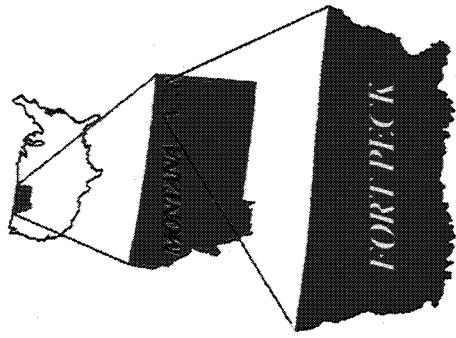
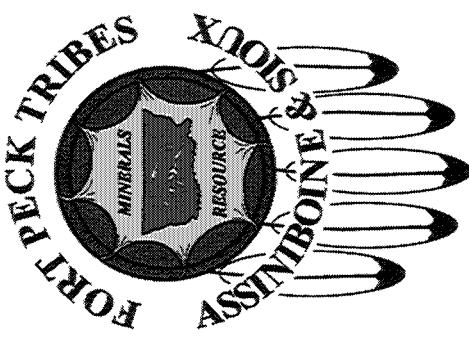
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Assessment Of Hydrocarbon Seepage On Fort Peck



Comparison Of Surface Exploration Techniques

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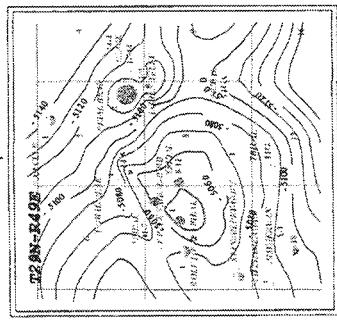
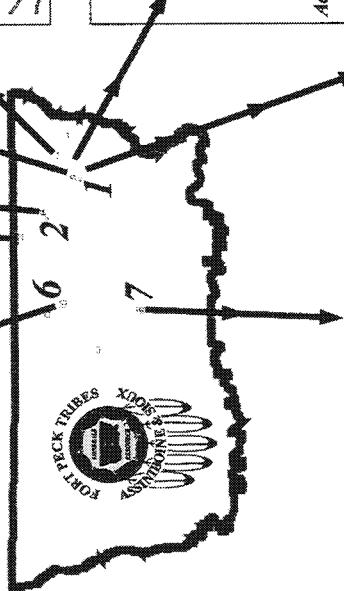
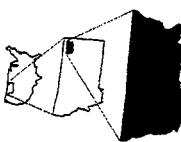
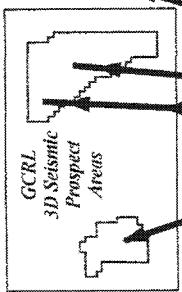
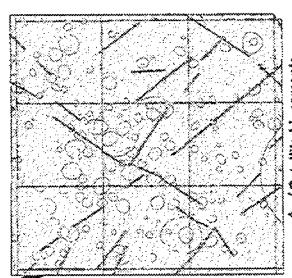
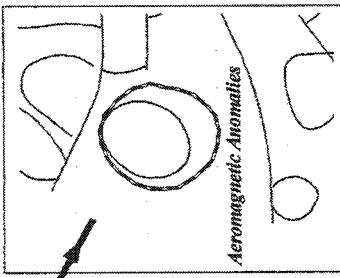
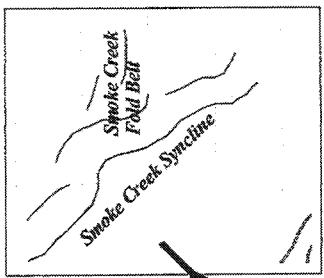
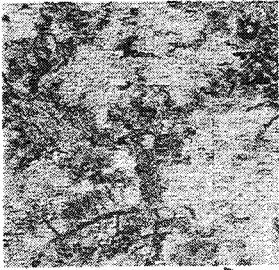
- U.S. DEPARTMENT OF ENERGY
- NATIONAL ENERGY TECHNOLOGY LABORATORY



**ASSESSMENT OF HYDROCARBON SEEPAGE
ON THE FORT PECK RESERVATION,
NORTHEASTERN MONTANA:**

**U.S. Department of Energy Grant # DE-FG26-M0BC15192,
Funded by the National Petroleum Technology Office.**

**Contractor: Lawrence M. Monson, Minerals Resource Office,
Assiniboin & Sioux Tribes, Fort Peck Reservation, Montana.**



Palominio Oil Field

Legend:
Satellite Lineaments
Satellite Curvilinear Roads
Townships

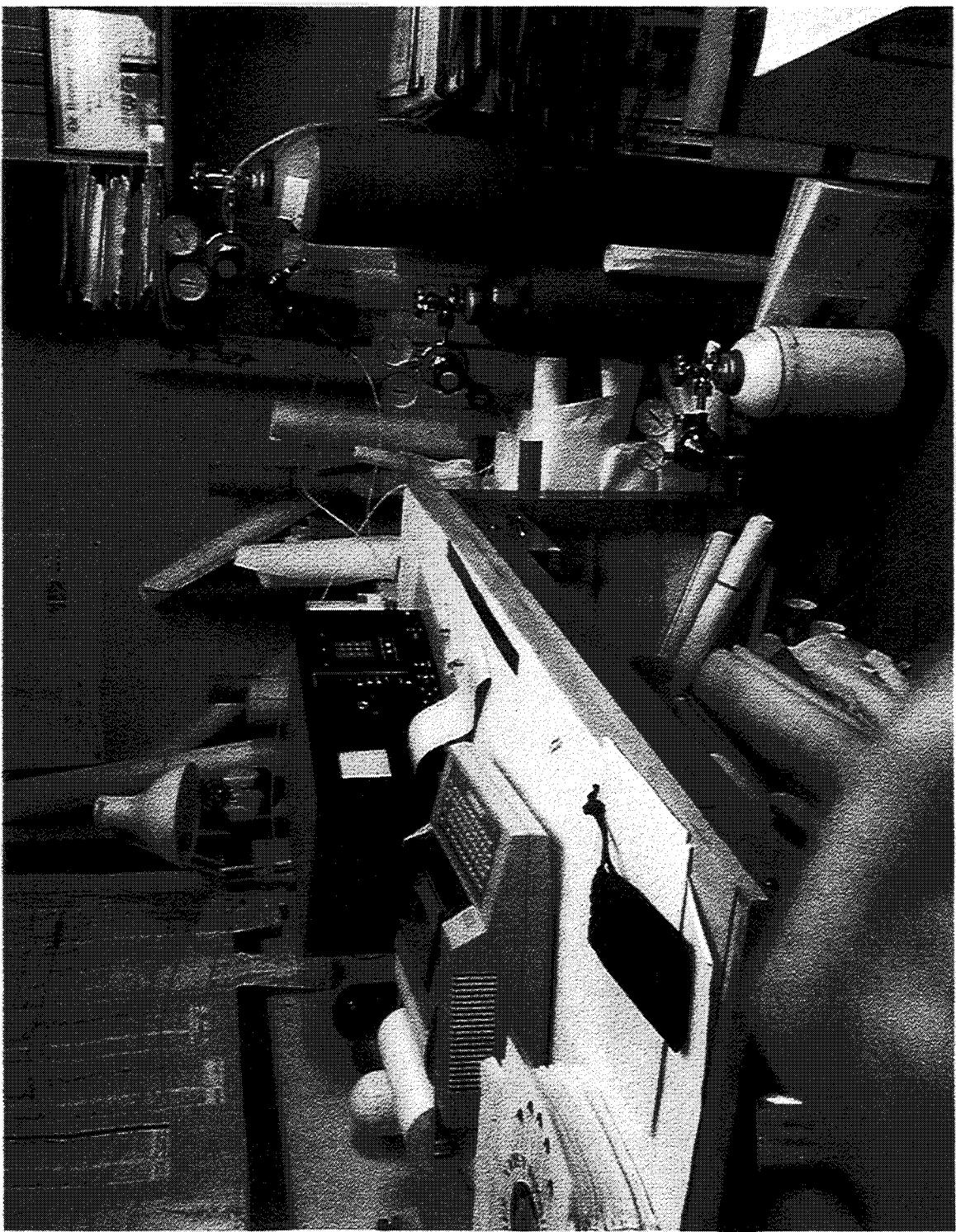
SURFACE METHODS TESTED

- 1. SOIL GAS
- 2. ACID EXTRACT
- 3. HEAD GAS
- 4. THERMAL DESORPTION
- 5. UVF (2)
- 6. MICROBIAL (2)
- 7. IODINE
- 8. MAGNETIC SUS.
- 9. Eh, pH, K
- Methane – nButane
- Methane – nButane
- Methane – nPentane
- Methane – nHexane
- PAC – 2 & 3 ring
- Selective H/C Cultures
- Magnetization Ability
- REDOX & Conductivity

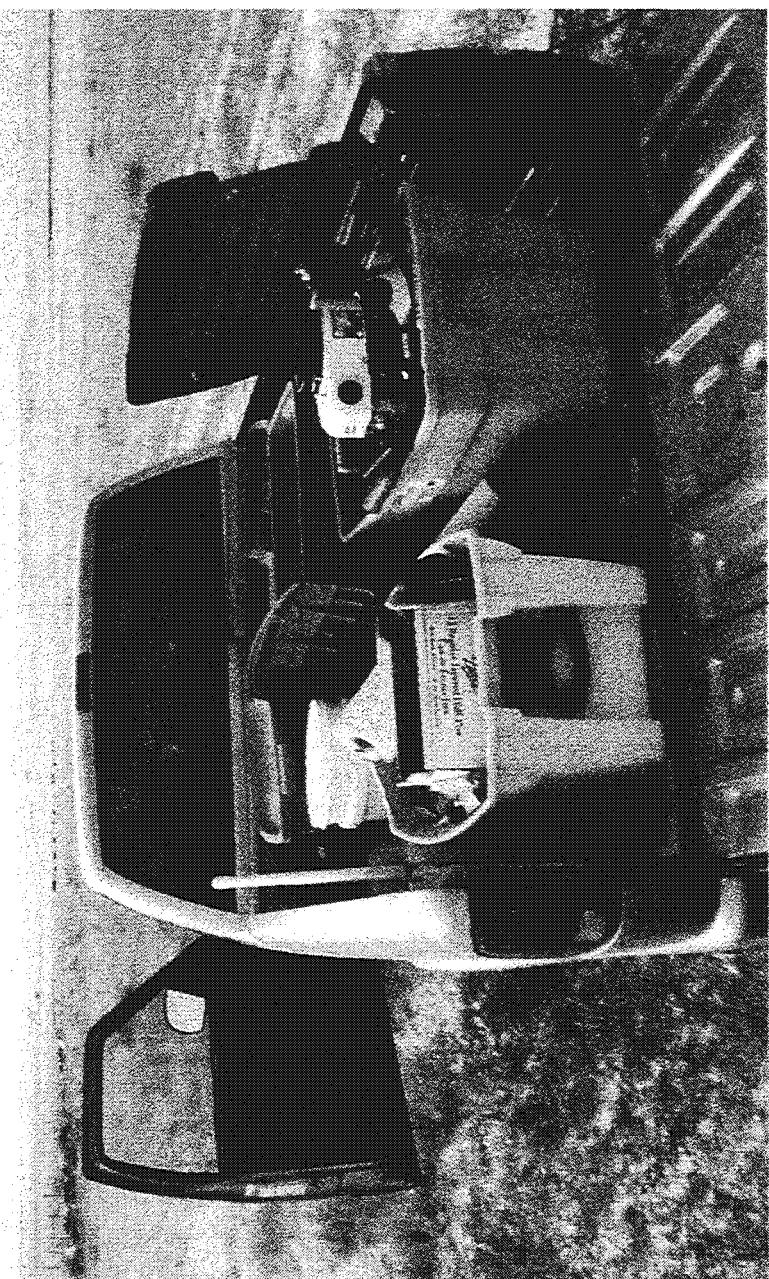
THEORETICAL BASIS

- 1. SOIL GAS
 - Vertical Micro-seepage directly sampled.
- 2. ACID EXTRACT
 - Acid frees occluded light gases.
- 3. HEAD GAS
 - Water dissolves adsorbed light gases.
- 4. THERMAL DESORPTION
 - Heat frees adsorbed light gases.
- 5. UVF (2)
 - Fracture migrated med. Wt. Gases.
- 6. MICROBIAL (2)
 - H/C feeding bacteria in soil
- 7. IODINE
 - H/C gases pull Iodine from air or soil.
- 8. MAGNETIC SUS.
 - Reducing environment ppt. Fe minerals
- 9. Eh, pH, K
 - Lower Eh, higher pH w/halo, and Conductivity halo caused by H/C seepage.

Gas Chromatograph



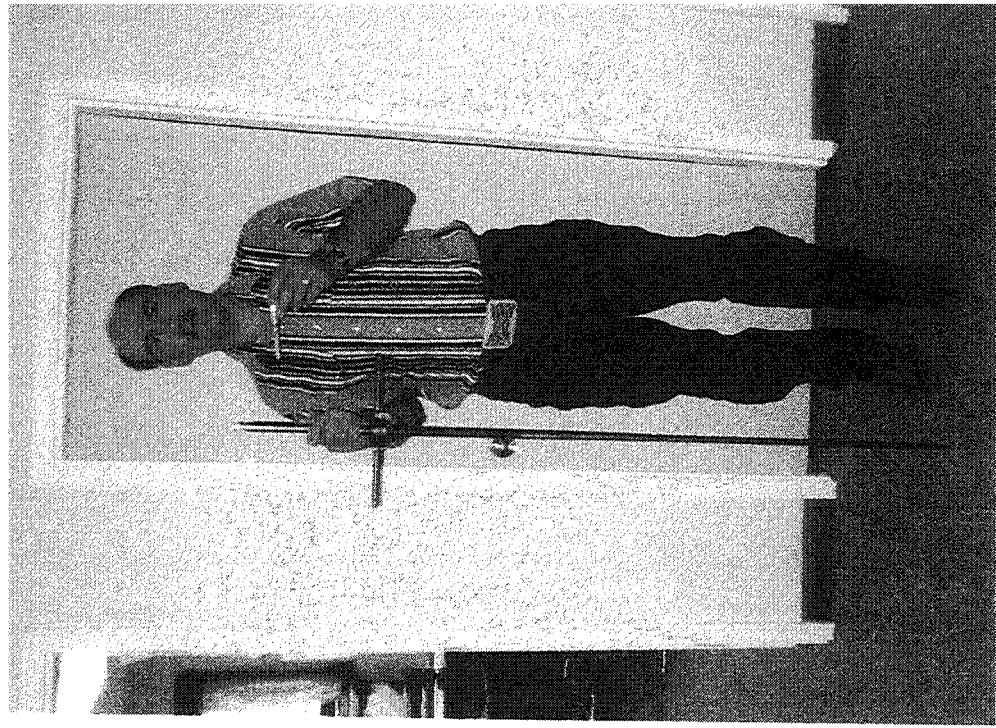
Field Operations



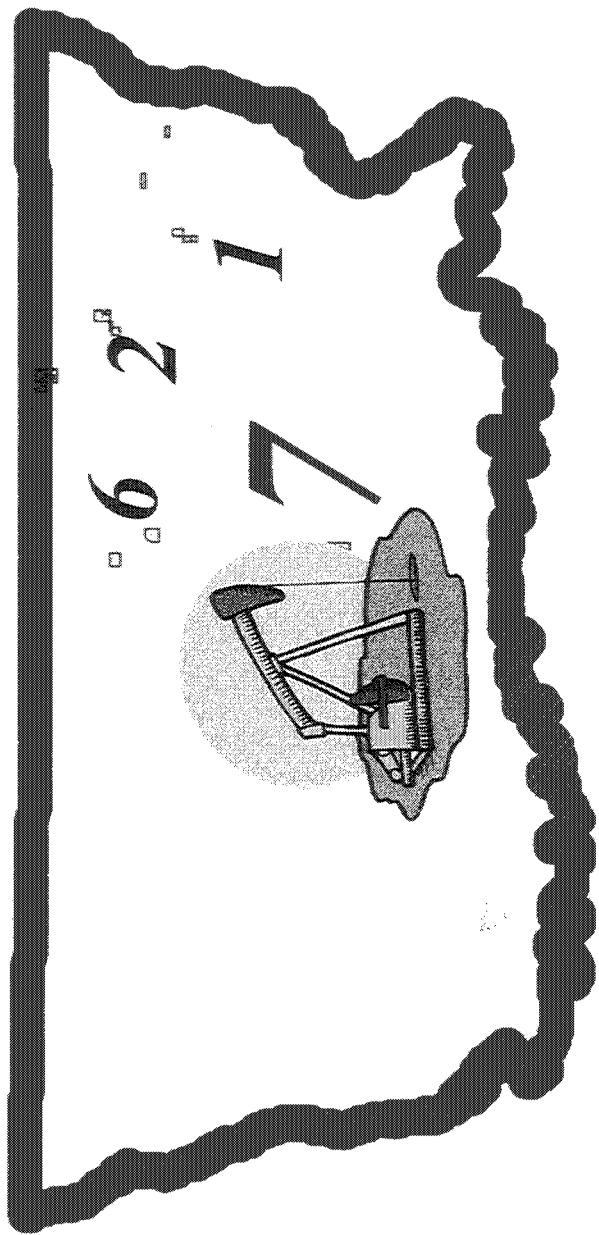
Field Sampling

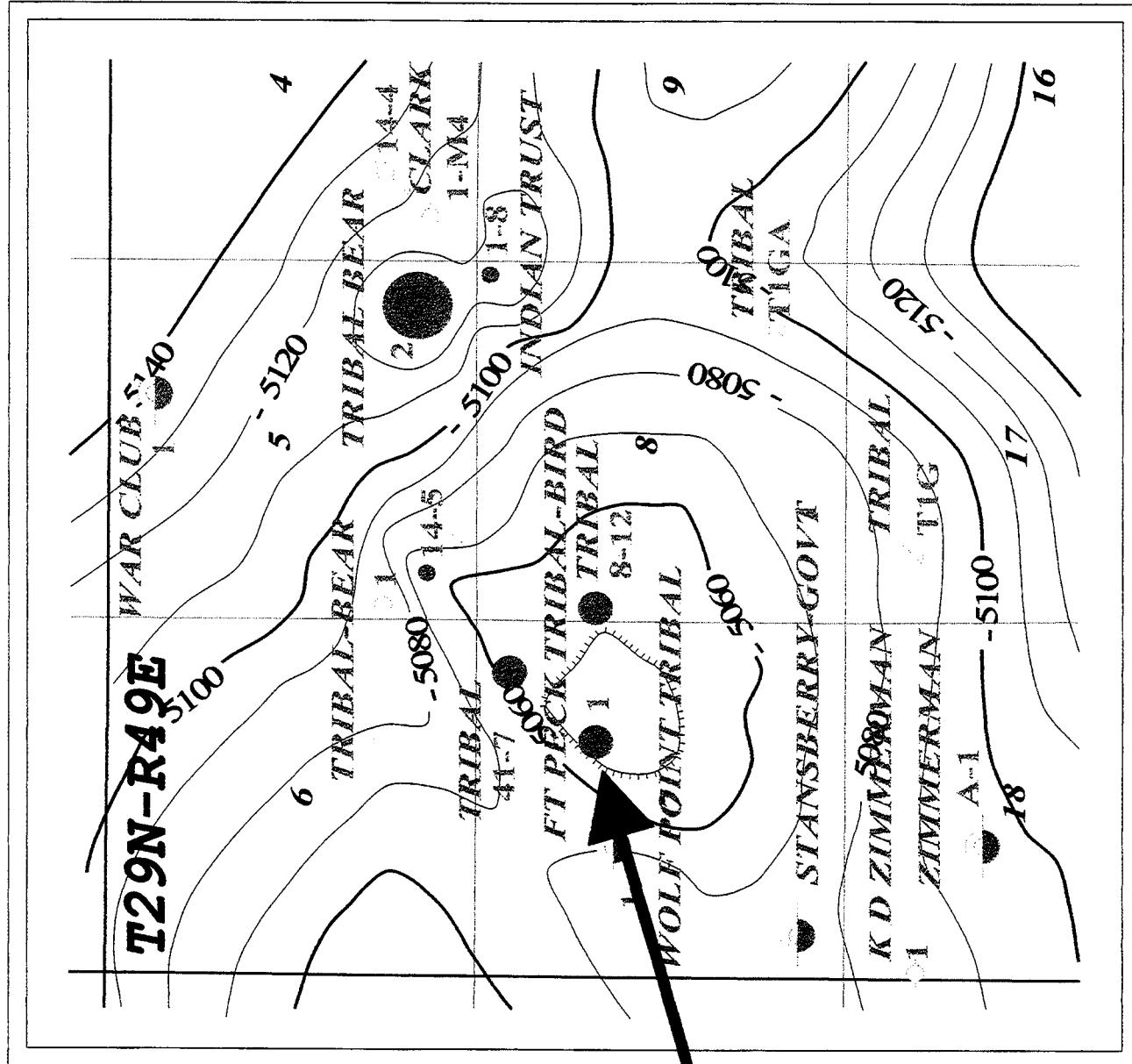


Geologist Labor



AREA 7: PALOMINO OIL FIELD

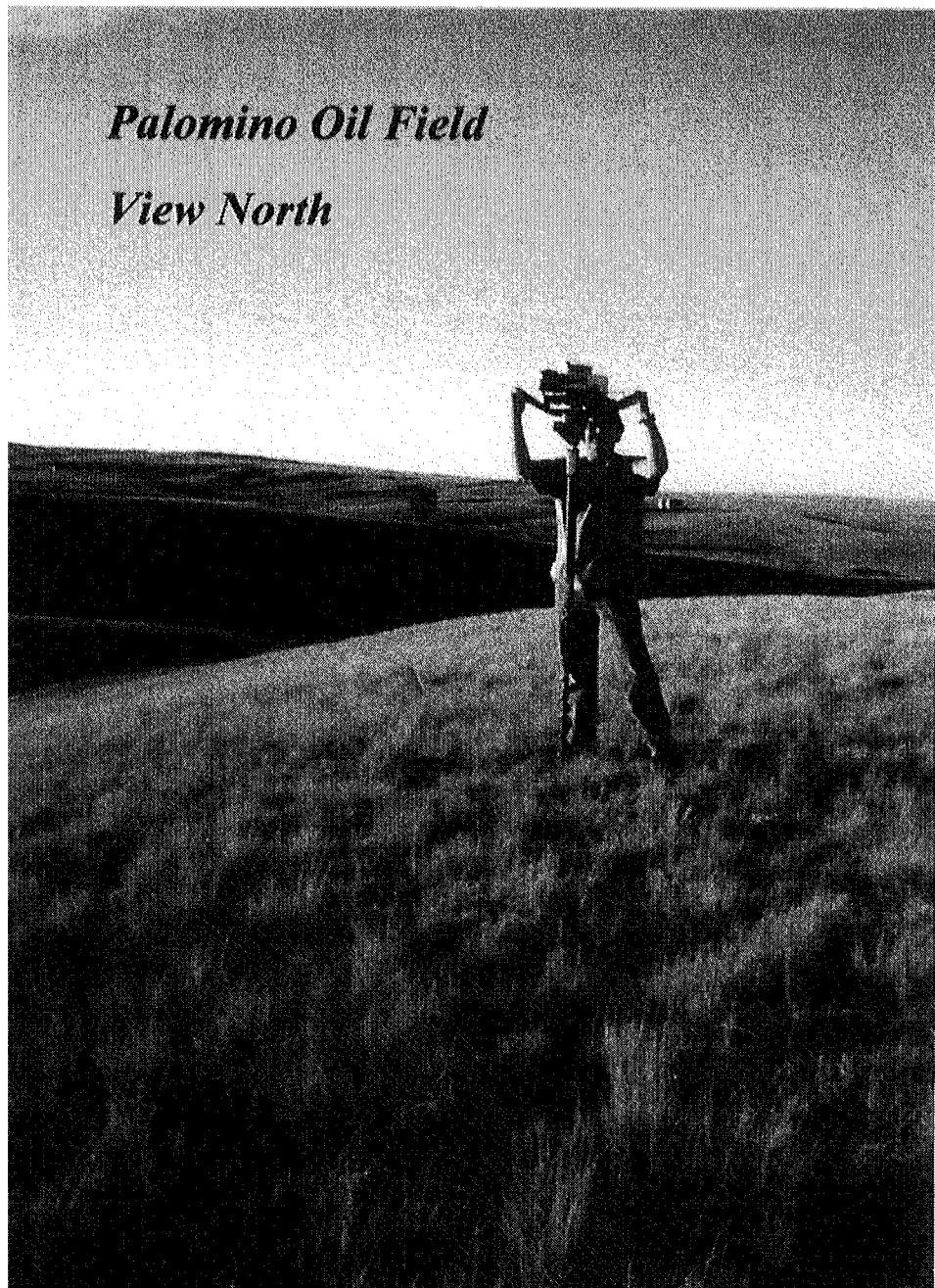




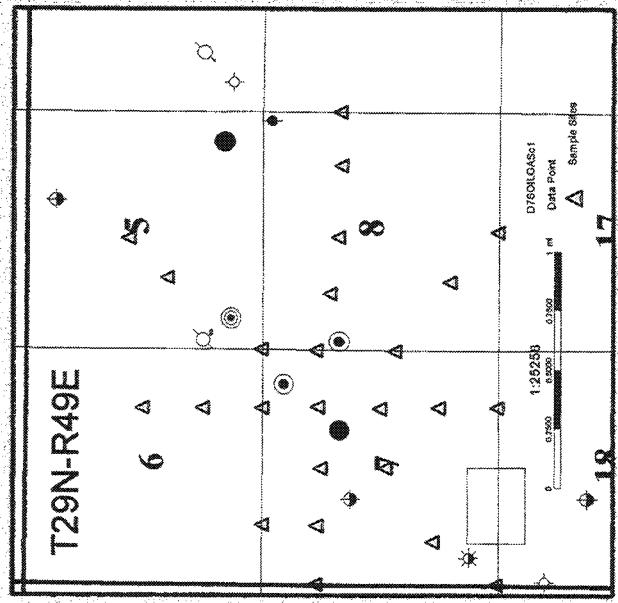
1.4 MM BO

Palomino Oil Field

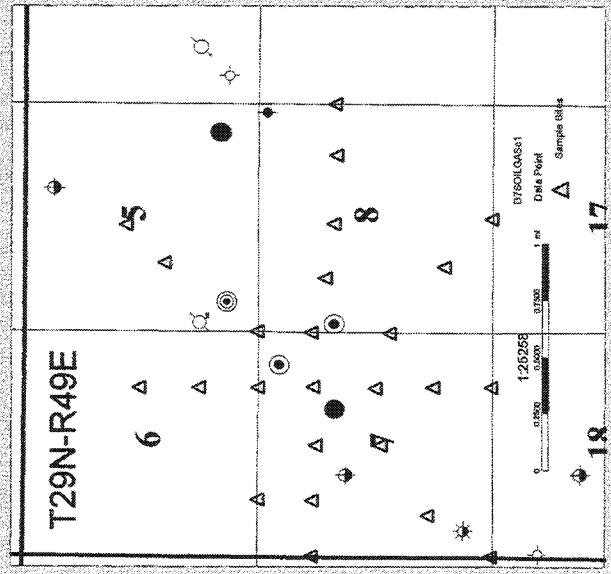
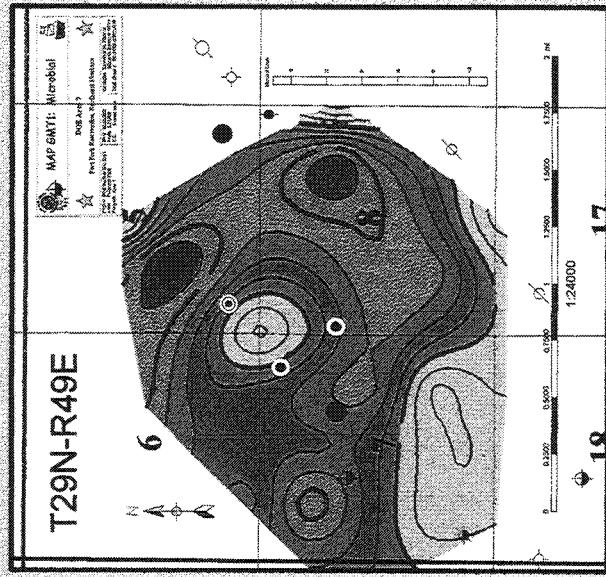
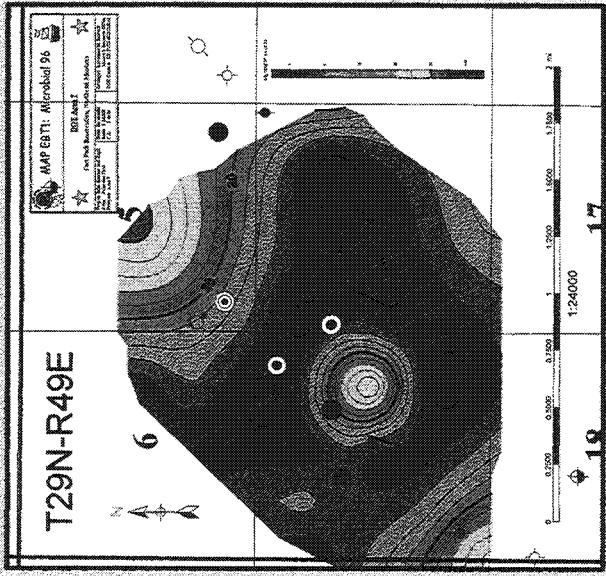
View North



PALOMINO OIL FIELD

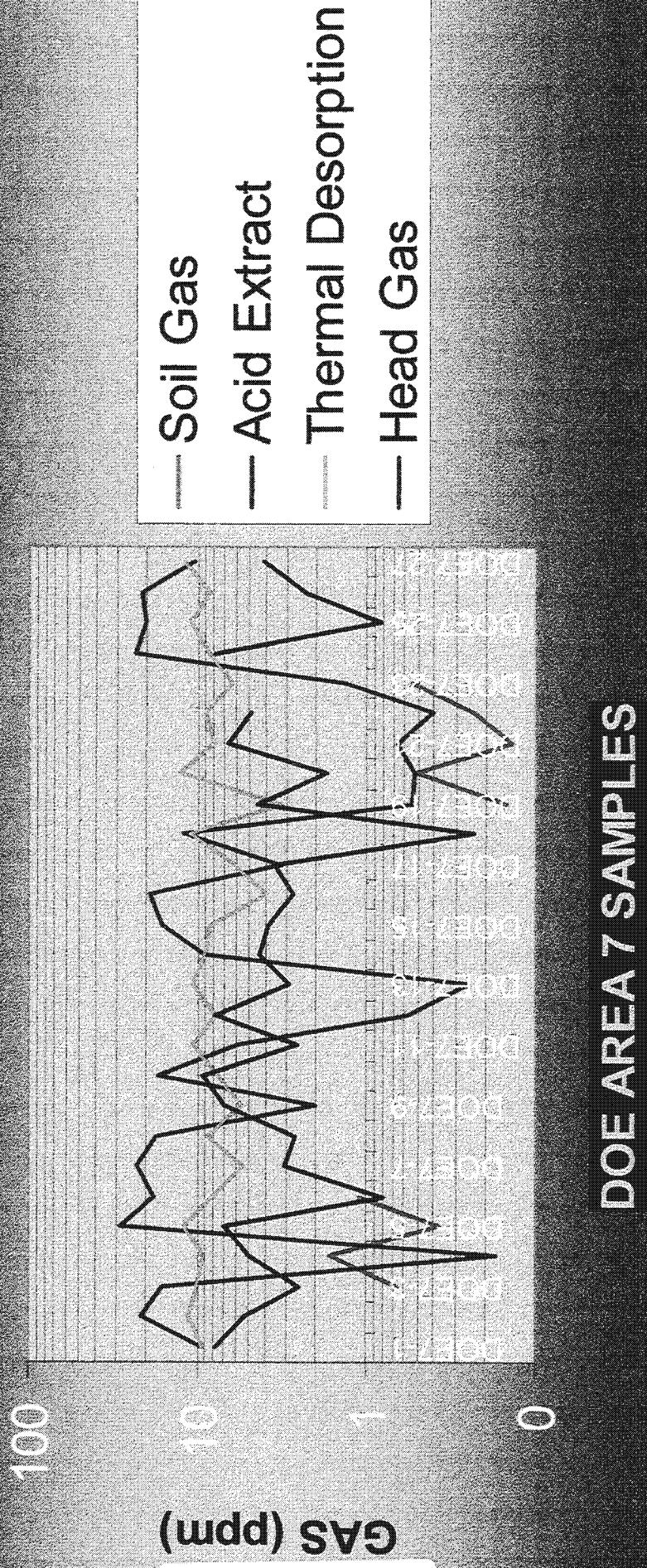


PALOMINO OIL FIELD



DOE GRANT AREA 7

PROPANE COMPARISON



DOE AREA 6

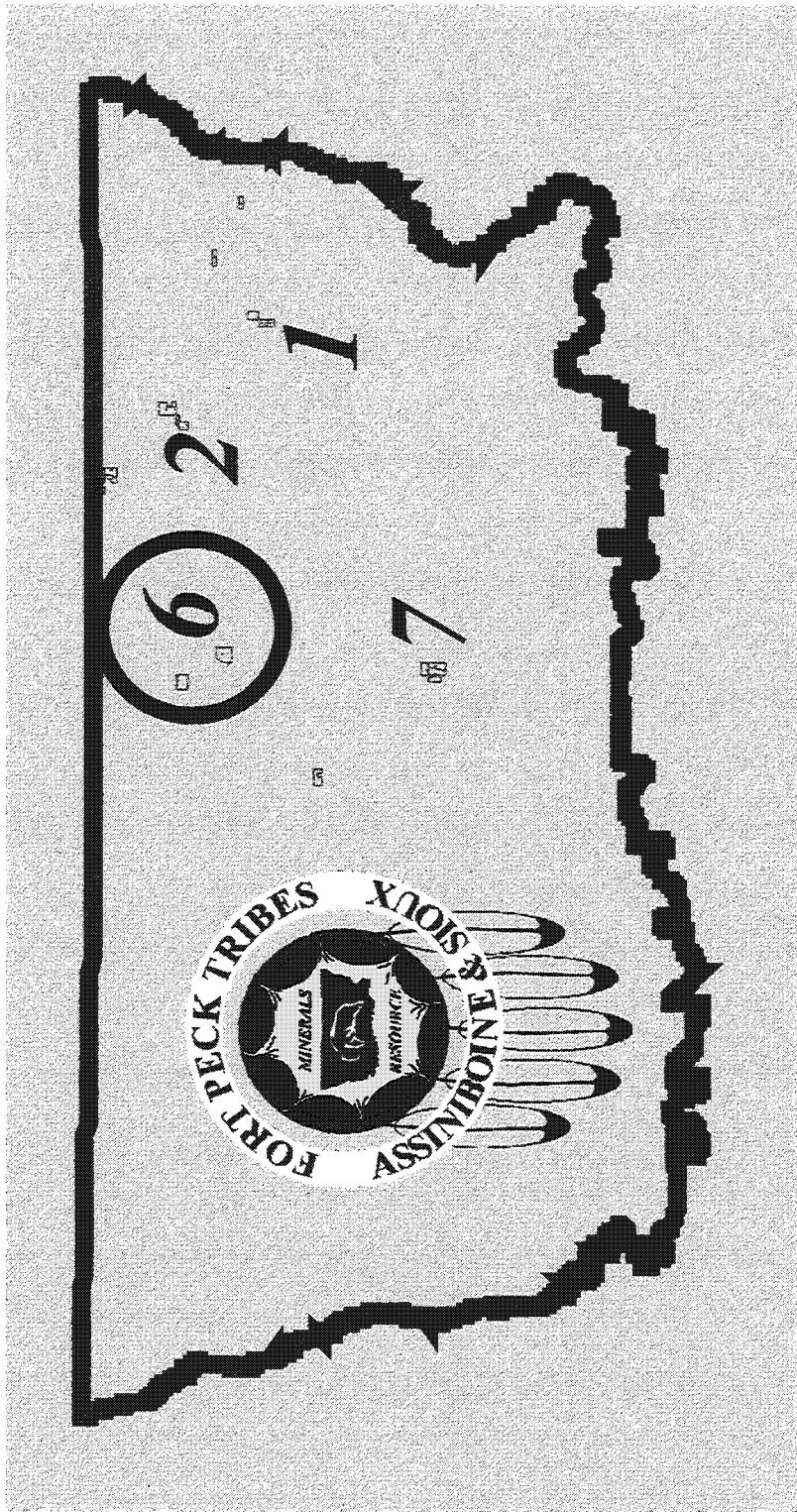
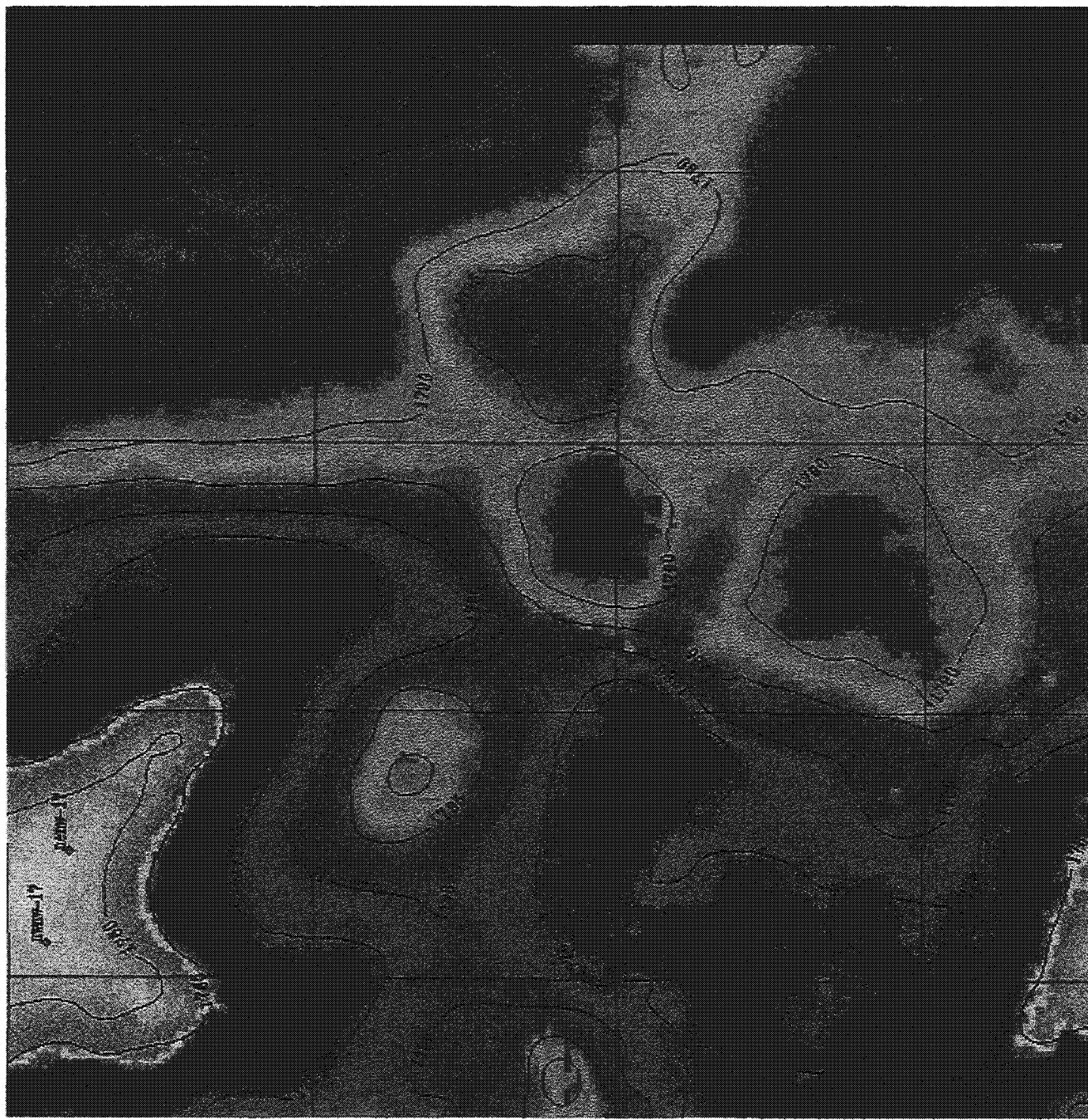
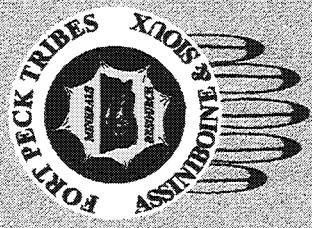


Fig. 14. Wicape 3D – Tobago Prospect – Winnipeg Shale time structure

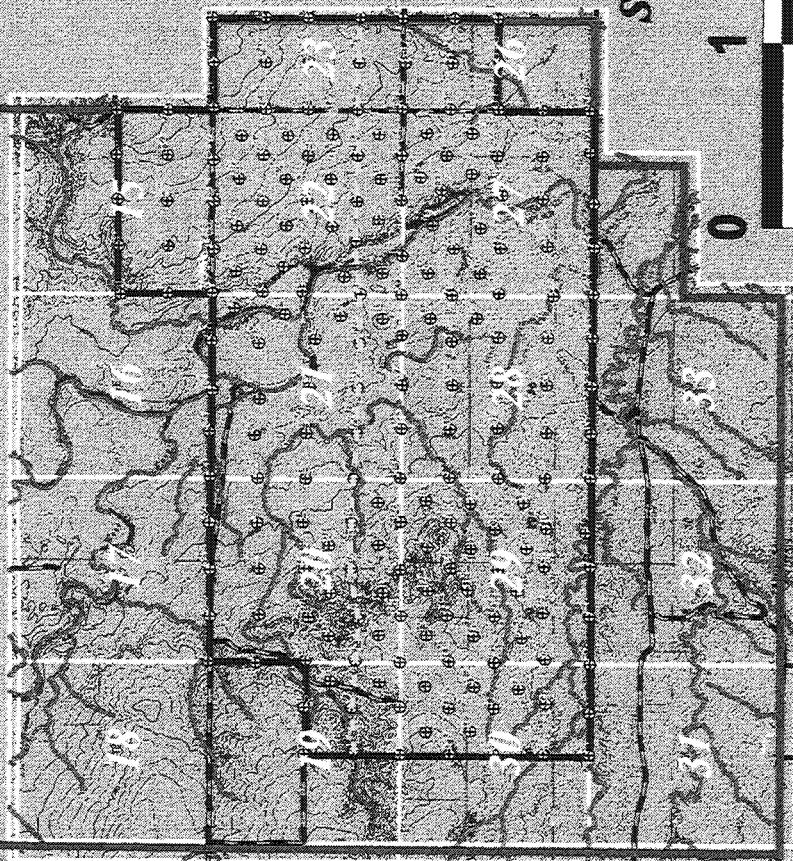
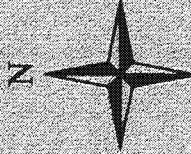


DOE GRANT AREA 6

BASE MAP: Sample Sites, Topography, and Streams

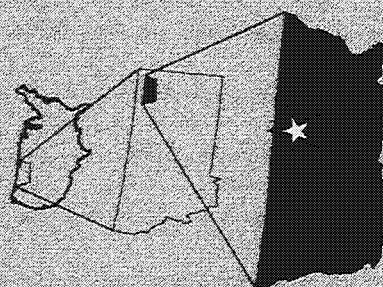


GCRL
WICPAE
3D PROSPECT

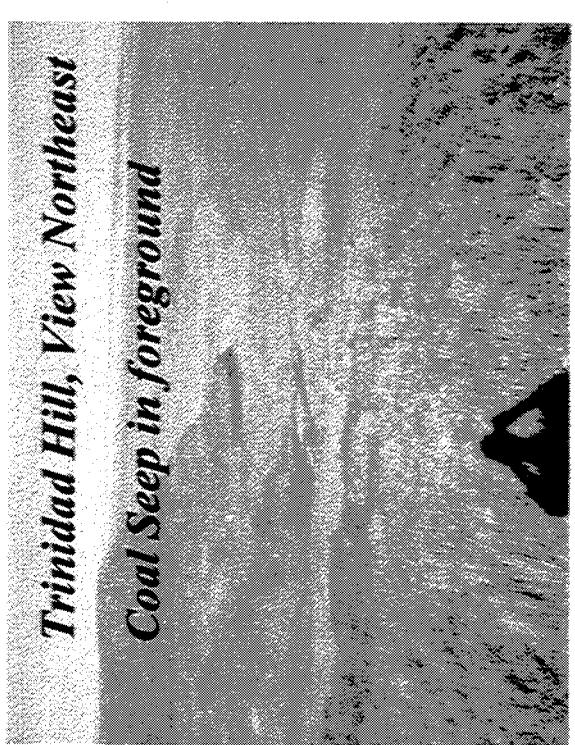
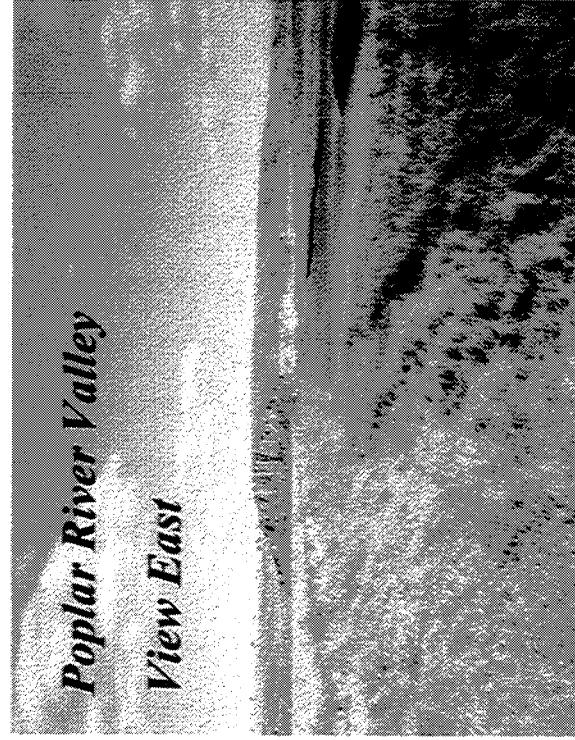
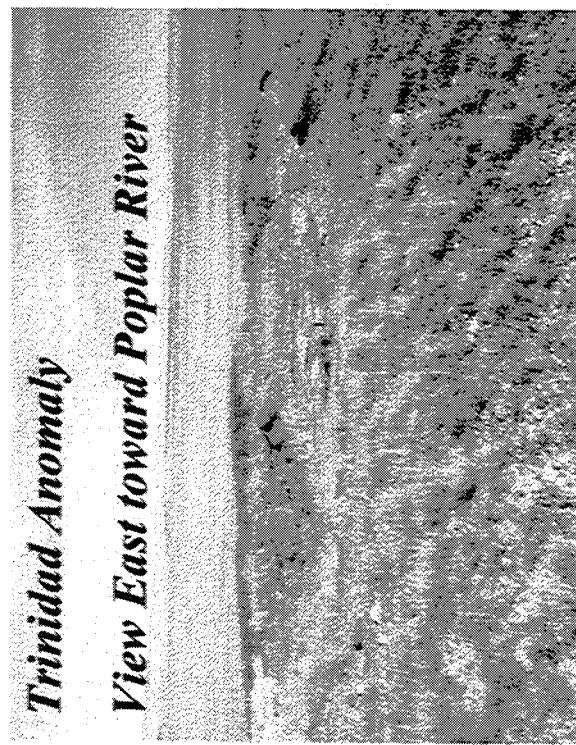
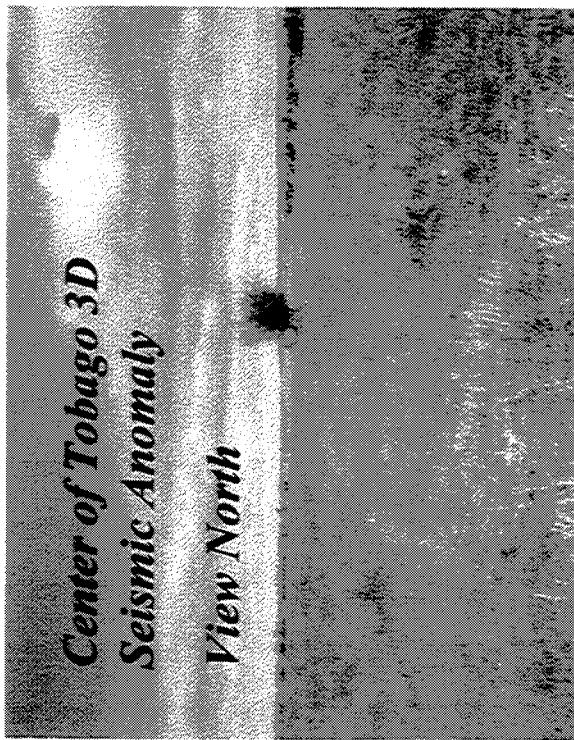


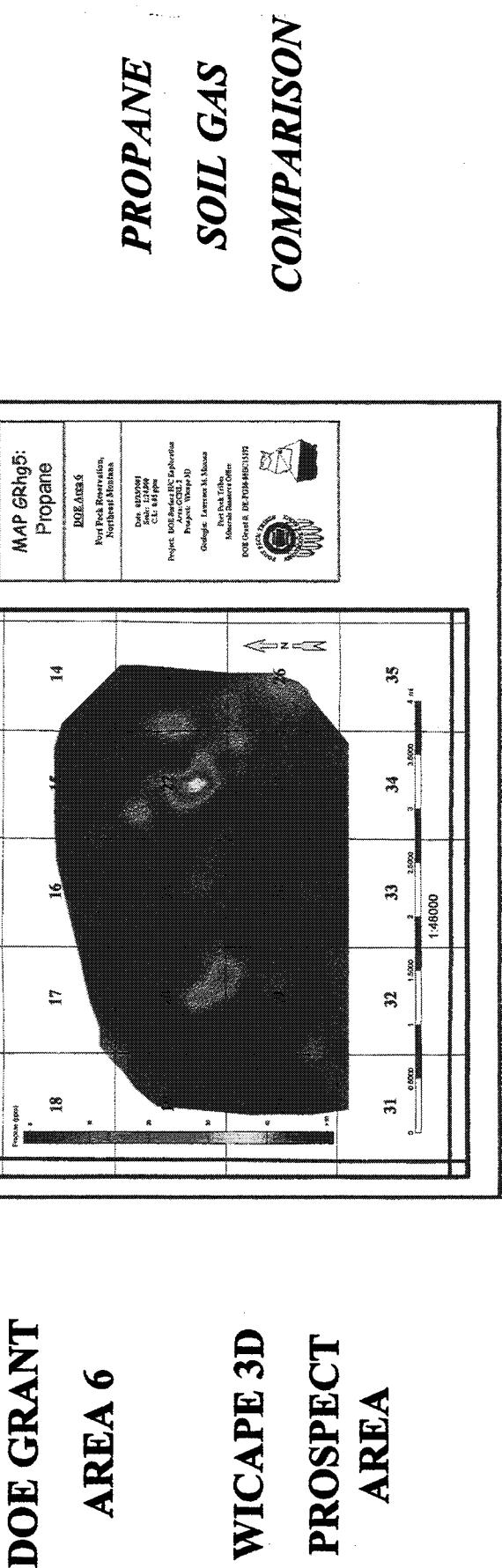
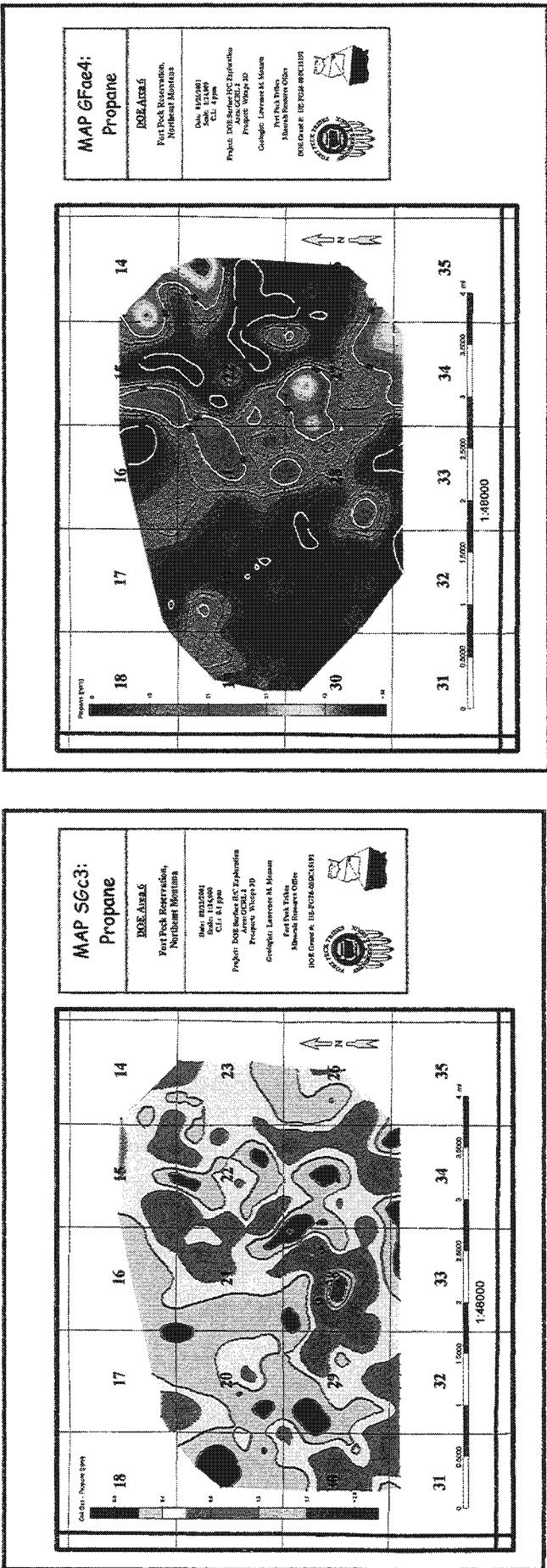
Scale = 1:48,000

3 Miles

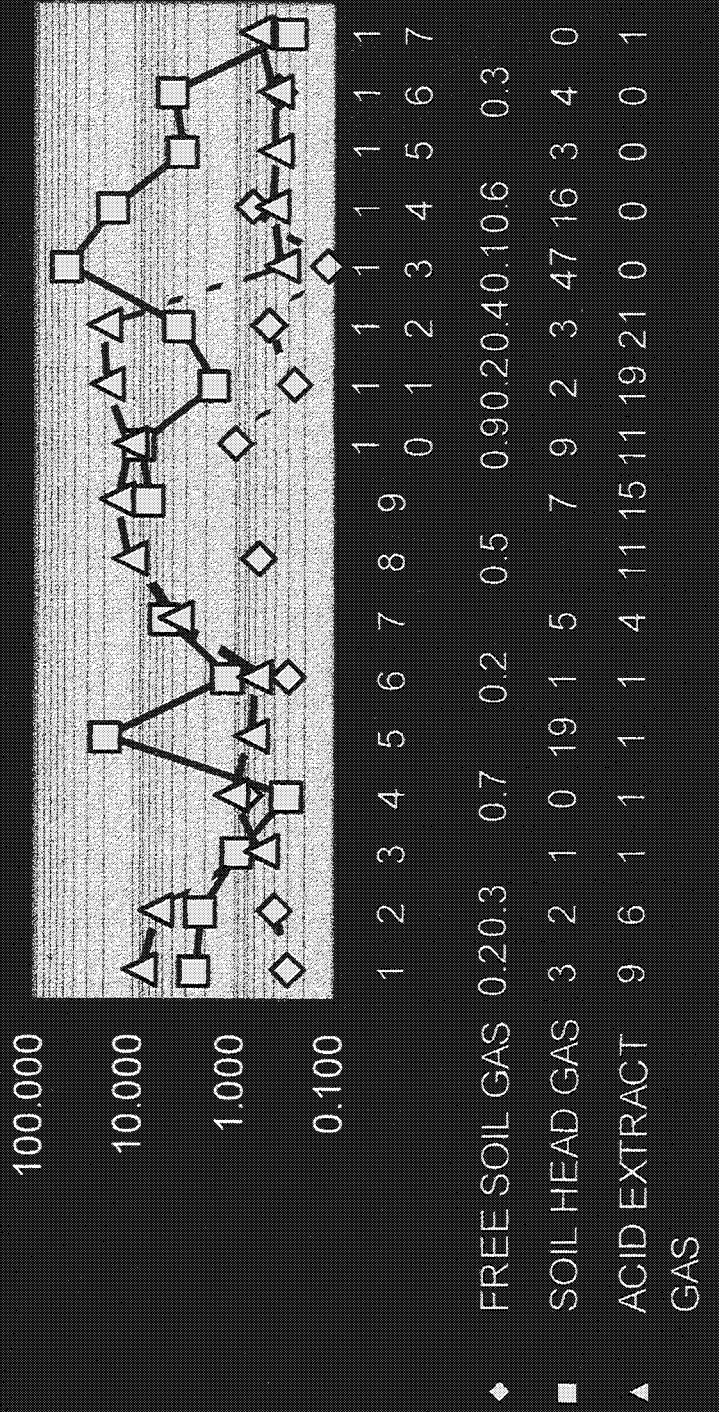


Area 6 Field Views

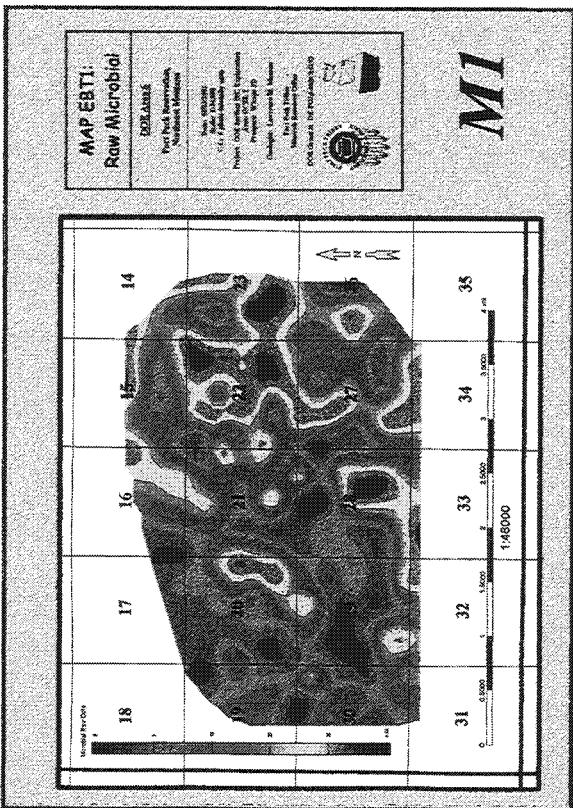
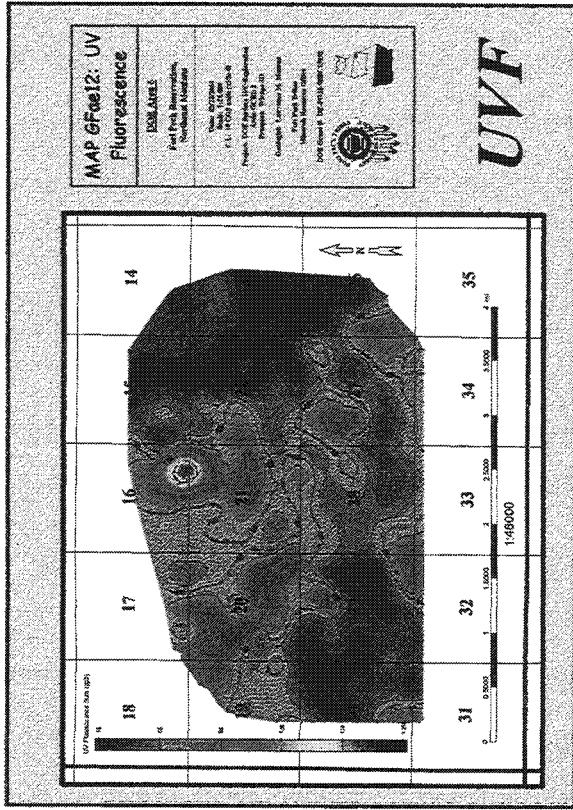
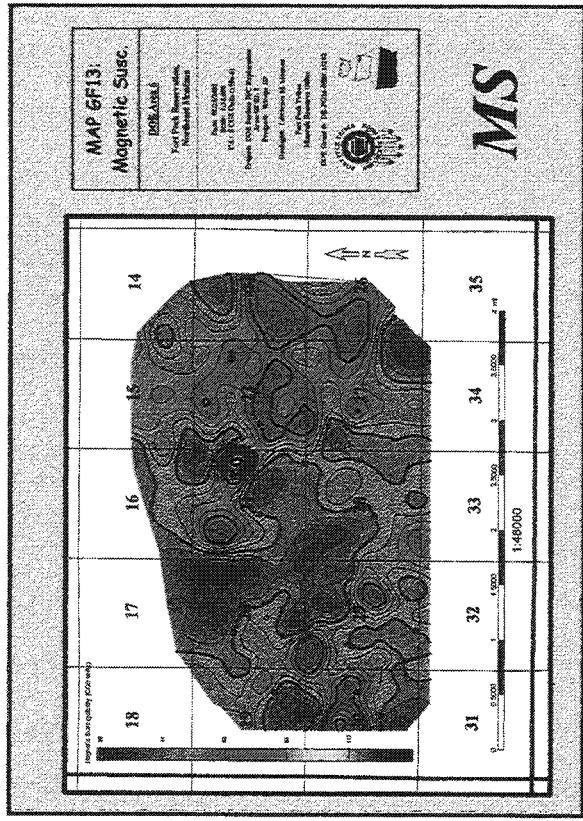




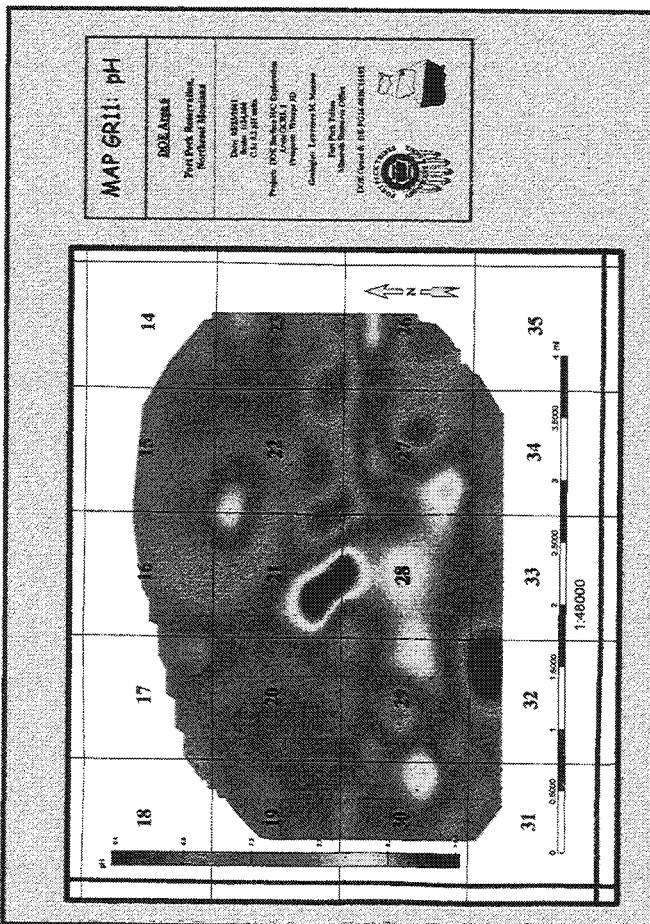
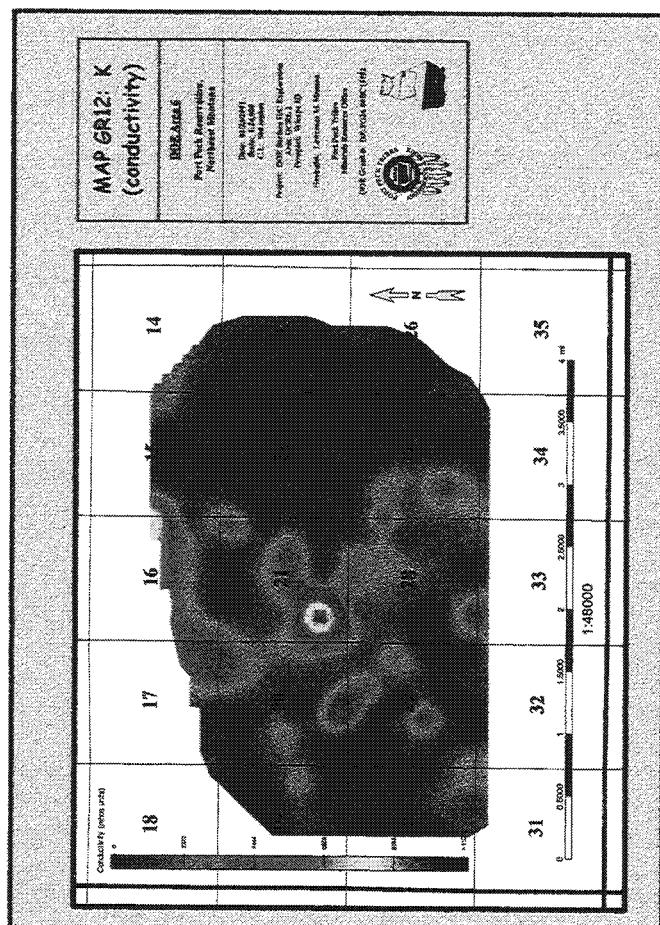
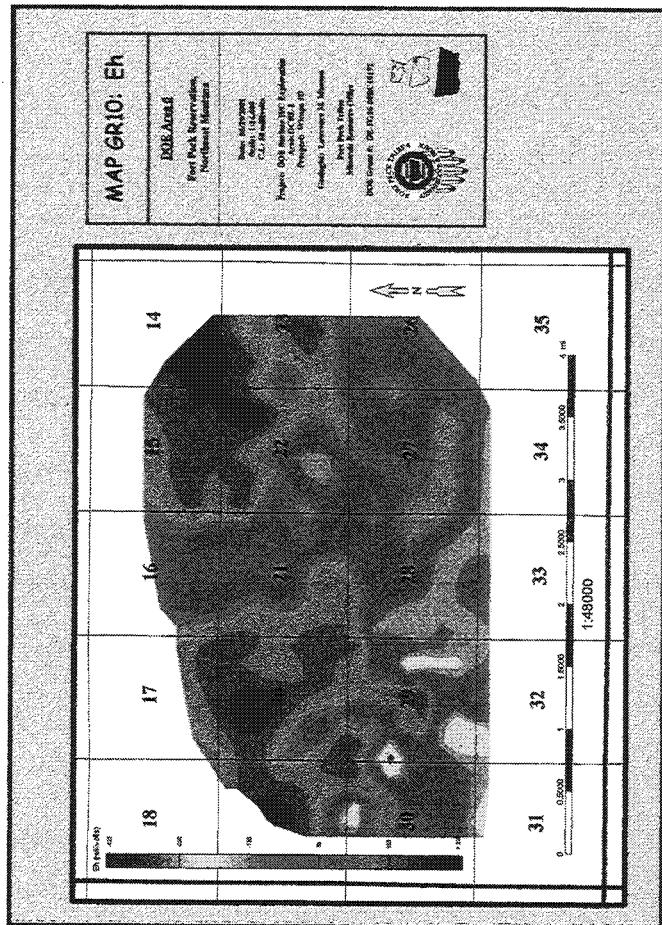
DOE AREA 6 SOIL GAS COMPARISON



PPM Propane



DOE GRANT AREA 6: WICAPE 3D PROSPECT



OTHER INDIRECT HYDROCARBON INDICATORS

Coal Seep



PHASE I PRELIMINARY OBSERVATIONS

- 1. *Head gas* samples collected by power auger correlate the best to oil production and to 3D seismic anomalies.
- 2. *Thermal Desorption* analysis correlates well to production.
- 3. *Direct soil gas* measurements are five to ten times less sensitive and do not correlate as well.
- 4. Both *microbial* methods show depletion over oil field. 3D anomaly correlated in Area 6.
- 5. *Acid extract* gases depleted over oil field and correlate 3D anomalies, but also show strong halo pattern.
- 6. *Iodine, magnetic susceptibility, and UVF* methods difficult to interpret. May show depletion and halo anomalies.
- 7. *Eh, pH, and K* show halo/depletion or inverse anomalies over production and only Eh may confirm gas seepage over 3D anomalies.